Marx-Biased Technical Change and the Neoclassical View of Income Distribution

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Abstract

This paper empirically tests two competing views about capital-labour substitution at the aggregate level in capitalist economies: the classical model with Marx-biased technical change versus the neoclassical model. Following Foley and Michl (1999), the classical viability condition of technical change is used to draw out two different hypotheses about the profit share in national income corresponding to the two competing models. A stochastic version of the viability condition is empirically tested with data from the Extended Penn World Tables 2.1 using a simple cross-country estimation strategy. It is found that the data overwhelmingly rejects the neoclassical theory.

JEL Codes: B51, O1.

Keywords: classical economic growth, biased technical change, marginal productivity.

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1 Introduction

In the last decade, several economists working in the classical-Marxian tradition have developed a coherent alternative framework to study the phenomenon of long-run economic growth and technical change in capitalist economies.¹ This framework differentiates itself from the mainstream approach by eschewing the use of a smooth aggregate production function, the starting point of all neoclassical growth analysis. Instead, this alternative framework, uses the device of the growth-distribution (GD) schedule for studying growth, distribution and technical change. This alternative framework, it is obvious, has taken serious note of the critique of the aggregate production function approach that came to the fore during the Cambridge capital controversy, and consciously builds on the early pioneering work of Sraffa (1960).²

A technique of production is defined, in this alternative framework, as the pair \((x, \rho)\), where \(x\) is the labour productivity and \(\rho\) is the output-capital ratio, also referred to in the literature as capital productivity. Technology, at any point in time, is understood as the collection of all usable techniques of production. Technological change under capitalism, in this view, amounts to the addition of newer techniques of production to technology over time. One of the ‘stylized facts’ about economic growth under capitalism is that technological change is not neutral, in the sense of symmetrically improving the productivity of labour and capital. For a large cross-section of capitalist countries and for significant periods of time, technological change is observed to be biased towards labour: while labour productivity grows over time, capital productivity stagnates or falls through time³. Since this empirical fact corresponds closely to Marx’s depiction of the capital accumulation process and technical

¹See, for instance, Duménil and Lévy (1995); Foley and Marquetti (1997); Foley and Michl (1999); Michl (1999); Michl (2002); Foley and Michl (2004); Foley and Taylor (2006).
²For a discussion of the Cambridge capital controversy, see Cohen and Harcourt (2003). As I point out later on, I have avoided addressing some of the critical issues of aggregation raised during this debate by working in a one-commodity framework.
³For evidence on this see Foley and Michl (1999) pp. 37-41; and Duménil and Lévy (2004).
change under capitalism, Foley and Michl (1999) call this Marx-biased technical change (MBTC).

An important proposition about Marx-biased technical change that emerges from this alternative theoretical framework is the classical viability condition. This relates to the condition that must be satisfied for biased technical change to be viable, where viability is understood as the adoption of the new technique of production, as it becomes available, by profit-maximizing entrepreneurs. As we show below, following Foley and Michl (1999), the classical viability condition can be used to draw out competing, testable implications about observable variables in the economy. These competing testable implications refer, respectively, to the neoclassical and the classical-Marxian theory of distribution, where the neoclassical theory implies equality of the current wage rate and the marginal product of labour, while the classical-Marxian theory allows the wage rate to exceed the apparent marginal product of labour. In this paper, I propose and carry out a simple empirical test to distinguish between the neoclassical and the classical theories of growth, technical change and distribution. Using data from the Extended Penn World Tables 2.1 (EPWT 2.1) and utilising a simple cross-country regression analysis, my test strongly rejects the neoclassical theory of distribution.

The rest of the paper is organized as follows. In the next section, I present a brief discussion of the growth-distribution schedule, an important device used in the alternative approach. In the following two sections, I derive the classical viability condition and a more generalized version of the viability condition; these sections draw heavily on Foley and Michl (1999). In the penultimate section I outline my empirical strategy, carry out the empirical analysis and present my main results. The last section concludes the discussion.
2 The Growth-Distribution Schedule

The economy under consideration, a simplified closed capitalist economy, is populated by three types of economic agents: capitalists, workers and entrepreneurs. Entrepreneurs organize production by using capital and labour, borrowing capital from its owners, the capitalists, and hiring workers on the labour market. Time is discrete, and there is only one good that is produced, consumed and saved; saved output is invested and becomes part of the capital stock in the next period. Income generated during the production process is divided between wages and profits, wages flowing to workers and profits to capitalists.\textsuperscript{4}

The growth-distribution (GD) schedule graphically represents two fundamental trade-offs that such an economy faces, the trade-off between consumption and the growth of capital stock (the social consumption-growth rate schedule), and the trade-off between wages and profits (the real wage-profit rate schedule).\textsuperscript{5} Denoting by $g_Y$ the growth rate of a generic variable, $Y$, where

$$g_Y = \frac{Y_{t+1}}{Y_t} - 1,$$

the social consumption-growth rate schedule is represented as

$$c = x - (g_K + \delta)k,$$  \hspace{1cm} (1)

where $c$ is the social consumption per worker, $x$ is the labour productivity, $g_K$ denotes the growth rate of the capital stock, $\delta$ is the rate of depreciation of the capital stock, and $k$...
denotes the capital stock per worker.

The second trade-off that can be represented through the GD schedule is the trade-off between wages and profits, the types of income corresponding to the two fundamental classes of capitalist society: workers and capitalists. This trade-off represents the class struggle over the distribution of the net social product of society and will be called the real wage-profit rate schedule; it is represented as

$$w = x - kv,$$  \hspace{1cm} (2)

where \(w\) is the wage rate (total wage bill per worker), \(v\) is the gross rate of profit and \(x\) and \(k\) are as before.\(^6\)

Both these trade-offs, (1) and (2), are depicted in Figure 1 and is together called the growth-distribution (GD) schedule. The GD schedule is a negatively sloped straight line, alternatively viewed in \(v - w\) space or in \((g_K + \delta) - c\) space; the negative of the slope of the schedule is the capital intensity of production, \(k\). Note that the schedule hits the vertical axis at a value of \(x\) (the labour productivity) and the horizontal axis at a value of \(\rho\) (the capital productivity).

In the economy we are studying, the best-practice technique of production in any period is represented by the two ratios \(x\) and \(\rho\); the two together also determines the capital intensity of production, \(k = x/\rho\), which is the unique slope of the GD schedule. Hence, the GD schedule also represents the best-practice technique of production in use in the economy in the current period. Technical change, in this framework, is represented by changes in the techniques of production, i.e., changes in \(x\) and in \(\rho\), and can be graphically represented by shifts of the GD schedule.

I want to point out that by working in a simplified, single-commodity world, I am avoiding

\(^6\)For details of derivation of the GD schedule see Chapter 2, Foley and Michl (1999).
some of the important issues of aggregation in multi-commodity economies that were thrown up during the Cambridge controversy.\footnote{For an introduction to the issues involved see, for instance, Foley and Michl (1999), pp. 61-66, and Cohen and Harcourt (2003).} With more than one produced commodity, there would still be a downward-sloping wage rate-profit rate schedule for any technique, but unless the numeraire is the “standard commodity” corresponding to the technique, the wage rate-profit rate schedule will not be linear. Furthermore, even though in a multi-commodity production system there will be a downward sloping social consumption-growth rate schedule.
for each technique, it will not necessarily coincide with the wage rate-profit rate schedule, as in a one-commodity world. These are some of the critical issues that will need to be addressed if this analysis is sought to be extended to a full-blown multi-commodity system, but in a single-commodity system the GD schedule is an adequate tool for analysis of growth and distribution; moreover, it is the outcome of applying the Sraffian method to an economy with a single produced commodity. With these preliminaries, we can now proceed to derive the classical viability condition.

3 The Viability Condition

Marx-biased technical change is the pattern of technical change characterised by increasing labour productivity and falling capital productivity. Figure 2 depicts the GD schedules in adjacent time periods, $t$ and $(t + 1)$, for an economy undergoing Marx-biased technical change. In period $t$, the economy is characterised by labour productivity $x$, wage rate $w$ and capital productivity $\rho$; in the next period, labour productivity increases to $x'$ while capital productivity falls to $\rho'$ due to Marx-biased technical change.

The classical viability condition captures the choice, relating to techniques of production, faced by an entrepreneur in period $t + 1$. The question she faces is this: should the new technique of production (represented by $x'$ and $\rho'$) be chosen or should she continue using the current technique (represented by $x$ and $\rho$), given that the wage rate has remained unchanged? It is obvious that a profit-maximising entrepreneur will choose the new technique only if it can generate a higher expected rate of profit at the going wage rate $w$, compared to the old technique. Thus, a new technique of production is defined to be *viable* if it promises a higher rate of profit at the current wage rate, compared to the old technique.

The efficiency frontier for a technology, is defined as “the northeast boundary of the real wage-profit rate schedules corresponding to its undominated techniques” (Foley and Michl
For the situation depicted in Figure 2, the efficiency frontier is ABC, where B is the switch-point. The viability condition relating to the new technique of production, \((x', \rho')\), also entails a specific relationship between the current wage rate and the switch-point wage rate, \(w^*\): a new technique of production emerging from a process of Marx-biased technical change is viable if \(w > w^*\), is not viable if \(w < w^*\) and is indifferently-viable is \(w = w^*\).

Recall that if an economy is characterised by a smooth (differentiable) production function (like a Cobb-Douglas production function used by neoclassical economists), then the
efficiency frontier of such an economy is a smooth convex (to the origin) curve in $v-w$ space. The tangent to the efficiency frontier corresponding to any wage rate, in this case, gives the GD schedule corresponding to that wage rate and thus summarises information about the chosen technique of production. Since a smooth production function like the Cobb-Douglas production function allows for a very high degree of substitutability between labour and capital, even a small change in the wage rate would lead profit-maximising entrepreneurs to choose a different technique of production.

This neoclassical scenario is depicted in Figure 3. Given a wage rate $w$, a profit-maximising entrepreneur would choose point A on the efficiency frontier. The tangent to the efficiency frontier, with the corresponding values of $x$ and $\rho$ for labour and capital productivity respectively, would be the corresponding GD schedule. When the wage rate increases to $w'$, point B on the efficiency frontier would be chosen; the tangent to the efficiency frontier at B would then become the new GD schedule. Thus, even a small change in the wage rate leads to a different technique being chosen, implying that every point on the efficiency frontier is a switch-point. Moreover, with a differentiable production function, and assuming that there are two factors of production, capital and labour, profit maximisation by entrepreneurs lead to the wage being equated to the marginal product of labour and the profit rate to the marginal product of capital. This further implies that the wage rate at a switch point of the efficiency frontier is always equal to the marginal product of labour.

Now we are in a position to use the viability condition to derive two alternative hypotheses, one representing the classical view and the other representing the neoclassical view. The neoclassical view implies, as we have just seen, that the economy is always at a switch-point. In terms of Figure 2, we see that this is equivalent to the proposition that $w = w^*$, i.e., that the current wage rate is equal to the switch-point wage rate, which is, in turn, equal to the apparent marginal product of labour. The classical view of production with Marx-biased technical change, on the other hand, allows the current wage rate to be higher than
the switch-point wage rate, and thus allows the current wage rate to be higher than the apparent marginal product of labour. Therefore, the classical view of viable Marx-biased technical change is equivalent, in terms of Figure 2, to the proposition that $w \geq w^*$, while the corresponding neoclassical position is $w = w^*$. Hence, we can test the classical versus the neoclassical view of capital-labour substitution by empirically determining whether the wage rate is greater than or equal to the switch-point wage rate (which, in turn, is equal to the apparent marginal product of labour); note, moreover, that while $w > w^*$ contradicts
the neoclassical view, the equality of the two, i.e., \( w = w^* \), would not go against the classical view.

To empirically operationalize this test between the competing theories of production, technical change and distribution, I will re-write the viability condition, following Foley and Michl (1999), in terms of the profit share in national income and some other technical parameters - the growth rates of labour and capital productivity - of the economy as follows:

\[
\pi < \pi^* = \frac{\gamma (1 + \chi)}{(\gamma - \chi)}, \tag{3}
\]

where \( \pi^* \) is called the viability parameter, \( \gamma \) is the rate of growth of labour productivity, \( \chi \) is the rate of growth of capital productivity and \( \pi \) denotes the share of profits in national income.\(^8\) This can also be written as

\[
1 - \pi > \frac{(-\chi)(1 + \gamma)}{(\gamma - \chi)}, \tag{4}
\]

which highlights the intuition behind the viability condition: a new technique of production which is labour-saving but uses more capital per unit of output will be chosen by a profit-maximising entrepreneur only if the labour component of the cost of production is higher than a certain threshold.

Thus, for an economy undergoing Marx-biased technical change, the viability of a new technique of production can be equivalently expressed using either the wage rate or the profit share. This equivalent characterisation has been summarized in Table 1 for easy reference. Using this equivalent characterization, we can now formulate the empirical test between the classical model of Marx-biased technical change versus the neoclassical production function-based model as follows: the neoclassical model implies that \( \pi = \pi^* \), while the classical model with Marx-biased technical change implies that \( \pi \leq \pi^* \).

\(^8\)For details of the derivation see Chapter 7, Foley and Michl (1999).
Table 1: Equivalent Characterizations of the Viability Condition

<table>
<thead>
<tr>
<th>New Technique is:</th>
<th>In terms of wage</th>
<th>In terms of profit share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viable</td>
<td>$w &gt; w^s$</td>
<td>$\pi &lt; \pi^*$</td>
</tr>
<tr>
<td>Not Viable</td>
<td>$w &lt; w^s$</td>
<td>$\pi &gt; \pi^*$</td>
</tr>
<tr>
<td>Indifferently Viable</td>
<td>$w = w^s$</td>
<td>$\pi = \pi^*$</td>
</tr>
</tbody>
</table>

It should be noted that the empirical test to discriminate between the neoclassical and classical views on capital-labour substitution and income distribution that has been outlined above is not a general test of the neoclassical view of growth against the classical view; it tests a specific version of neoclassical theory relating to the process of capital-labour substitution at the aggregate level summarized by a smooth production function. When neutral technical change, either Harrod-neutral or Hicks-neutral, is incorporated into the neoclassical framework, it is no longer possible to use the above test to distinguish between neoclassical and classical approaches (Foley and Michl (1999), p. 157.).

It is also necessary to point out that by working in a single-commodity economy I have avoided two important issues that would naturally arise in analyzing a multi-commodity system. First, in defining viability of techniques of production, entrepreneurs would need to take account not only of the wage rate but also of relative prices of commodities. Second, the analysis of Marx-biased technical change implicitly aggregates inputs into “capital” and “labour”; extensions of the analysis of this paper to a multi-commodity economy will involve dealing with serious problems of aggregation, as thrown up by the Cambridge Capital controversy.
4 A Generalized Viability Condition

So far, I have implicitly assumed that entrepreneurs make their choices expecting wages to remain unchanged; this might be a little unrealistic. Since real wages are known to increase in step with labour productivity in capitalist economies over the long term, entrepreneurs might factor this into their expectations; hence, entrepreneurs might expect wages to increase, more or less in tandem with labour productivity. What would be the analogue of the viability condition in such a scenario?

Suppose that the current best-practice technique of production is given by the pair \((x, \rho)\) and the new technique is represented by \((x', \rho')\), where the two are related through the following relations:

\[
x' = x(1 + \gamma)
\]

and

\[
\rho' = \rho(1 + \chi).
\]

Assume now that wages are expected to grow at some positive rate \(\eta > 0\), i.e.,

\[
w' = w(1 + \eta),
\]

where \(w'\) is the new wage expected to prevail in the next period. Let \(\pi\) denote the current profit share and \(\pi^e_n\) represent the profit share that would prevail if the new technique were to be adopted. Then,

\[
v^e_n = \pi^e_n \rho' = (1 - \frac{w'}{x'}) \rho' = \left\{1 - \frac{(1 - \pi)(1 + \eta)}{1 + \gamma}\right\} \rho(1 + \chi),
\]
where $v^e_n$ is the profit that entrepreneurs expect to obtain if the new technique is adopted \textit{and} wages grow at the expected rate, $\eta$. If, on the other hand, entrepreneurs continue using the current technique and wages increase at the rate $\eta$, then the expected rate of profit is given by $v^e_o$, where

$$v^e_o = (1 - \frac{w'}{x})\rho = \{1 - (1 - \pi)(1 + \eta)\}\rho.$$

The viability of technical change is ensured if $v^e_n > v^e_o$, which in this case becomes

$$\pi < 1 + \frac{\chi}{(1 + \eta) - \delta(1 + \chi)},$$

(5)

where $\delta = (1 + \eta)/(1 + \gamma)$ is the expected increase of the wage rate relative to the increase in labour productivity; this can be equivalently written, in analogous fashion to (4), as

$$1 - \pi > \frac{(-\chi)(1 + \gamma)}{(1 + \eta)(\gamma - \chi)}.$$  

(6)

I will call this the \textit{generalized viability condition}. There are two special cases of interest: (1) wages are expected to remain unchanged, and (2) wages are expected to grow at exactly the rate of labour productivity growth. These are undoubtedly the two extremes, and the actual movement of wages under capitalism lies somewhere in between.

If the wages are expected to remain unchanged, then $\eta = 0$; this implies that $\delta = 1/(1+\gamma)$. Substituting this expression for $\delta$ in (5) gives

$$\pi < \pi^* = \frac{\gamma(1 + \chi)}{(\gamma - \chi)},$$

(7)

which is the special case that is discussed in Foley and Michl (1999) and Michl (2002) and which I stated in (3). If, on the other hand, wages are expected to grow at the same rate as
labour productivity, then $\eta = \gamma$, and so $\delta = 1$. Substituting this in (5), we get

$$\pi < \pi_1^* = \frac{\gamma}{(\gamma - \chi)},$$

(8)

where $\pi_1^*$ is the viability parameter when wages are expected to grow in tandem with labour productivity. For later reference let me point out that I will use $\pi_1^*$ for part of the empirical analysis below in (11) and (12).

Note that since $\chi < 0$, if (7) is satisfied then so will be (8); thus if a technique is viable with stagnant wages, the it will also be viable when wages are expected to grow in tandem with labour productivity. This is true, moreover, for any positive rate of growth of expected wages. This is fairly intuitive: if a new technique of production that is labour-saving but capital-using is viable when wages are expected to remain unchanged, then it would certainly be viable when wages are expected to grow. Since the viability of such, i.e., Marx-biased, technical change is predicated on labour’s share in income being higher than some fixed threshold, as depicted in (6), viability with stagnant expected wages would imply viability with growing expected wages. I state this result as

**Proposition 1** If a new technique of production $(x', \rho')$ is chosen over an old technique $(x, \rho)$ by a profit-maximising entrepreneur, where $x' = x(1 + \gamma)$, $\rho' = \rho(1 + \chi)$, with $\gamma > 0$ and $\chi < 0$, when wages are expected to remain unchanged, then the new technique will also be chosen if wages are expected to grow at any positive rate, $\eta > 0$.

**Proof:** Comparing (4) and (6), and noting that $\chi < 0$ and $\eta > 0$ gives the result.
5 Empirical Analysis

5.1 Existing Results

Using the viability condition, Foley and Michl (1999) and Michl (2002) empirically tests the classical versus the neoclassical theory of growth and technical change by testing whether \( \pi^* > \pi \), where \( \pi^* \) is the viability parameter defined in (3) and \( \pi \) is the share of profits in national income. Using data for the OECD countries they present a scatter plot with \( \pi^* \) on the y-axis and \( \pi \) on the x-axis (see, for instance, Figure (7.2) in Foley and Michl (1999)) and visually inspect whether \( \pi^* \) is greater than \( \pi \) for each country. If most of the points fell on the 45° line, then that would provide evidence in favour of the neoclassical story of growth and distribution. But in fact most of the points lie above the 45° line which means that \( \pi^* \) is greater than \( \pi \) for most countries, and this provides evidence against the neoclassical viewpoint.

I reproduce their result in Figure 4, which is a scatter plot of \( \pi^* \) versus \( \pi \) for 25 OECD countries; data for this plot comes from the EPWT 2.1. To compute \( \pi^* \) according to (3), I have used the growth rates of \( x \) and \( \rho \) for the period 1963-2000 wherever data was available for the full period; otherwise I have started with the earliest year after 1963 and ended with the last year for which data was available.\(^9\) \( \pi \) has been computed in a similar manner as the average value of the annual profit share for the period 1963-2000 or the period for which data is available.

Compared to Foley and Michl (1999), I have added two more lines to the scatter plot: a 45° line passing through the origin and a regression line, the first to reproduce the results in Foley and Michl (1999) and the second to see the average relationship between \( \pi^* \) and \( \pi \) across countries. Each point on the scatter plot represents a country and the regression line

\(^9\)Note that in this analysis I am using the growth rate of \( x \) and \( \rho \) for the whole period and not the average annual compound growth rates.
shows the predicted values of $\pi^*$ for a regression of $\pi^*$ on a constant and $\pi$. The figure shows that the data for the 25 OECD countries for the period 1963-2000 provide evidence against the neoclassical view: most of the points lie above the 45° degree line. There are only three countries out of the twenty five which violate the viability condition in (3). The regression line has a slope of $-0.402$ though it is not statistically significantly different from zero.

![Viability Condition Scatter Plot, OECD](image)

**Figure 4:** *Viability Condition Scatter Plot, OECD*

A similar exercise is also carried out for all the countries in the EPWT 2.1 for which relatively complete data is available for the period 1963-2000; the result is presented in Figure 5. The scatter plot for all the countries is markedly different from that for the OECD countries. When all the countries are taken as a group there is considerable variation across countries as to whether the viability condition is satisfied. This is reflected in the fact
that, compared to Figure 4, Figure 5 has many more points below the 45° degree line. The regression line has a slope of −0.889 though it is not significant.

![Viability Condition Scatter Plot](image)

**Figure 5:** Viability Condition Scatter Plot

There can be at least two explanations for the difference between Figure 4 and Figure 5. The first explanation has to do with the fact that the non-OECD countries are vastly different from the OECD countries in terms of the structure and functioning of their economies; the OECD countries are advanced capitalist countries, while a large majority of the non-OECD countries are still far from completing their capitalist transformation. Since Marx-biased technical change can be expected to gain ground only with the deepening of capitalism, it might be argued that inclusion of the non-OECD countries in the sample (in Figure 5, for instance) reduces the validity of the comparison between the classical and neoclassical
visions.

The argument that the differences in Figure 4 and Figure 5 is driven by the differences in the depth of capitalism in the different countries is not incorrect but needs to be complemented with the recognition that in the last five decades world capitalism has made significant inroads into the peripheral social formations; the countries in the periphery of the world capitalist system have also seen the growth of capitalism, albeit of a distorted and stunted variety. Countries in the periphery that were able to catch-up with technological leaders can be expected, at the least, to display Marx-biased technical change.

The second explanation, which is the argument pursued in this paper, relies on a stochastic argument. This argument starts with the recognition that $\pi^*$ and $\pi$ are both random variables, because they are affected by several stochastic impulses emanating from the macroeconomy. Hence, testing the viability condition is best carried out not in a deterministic setting, as in Foley and Michl (1999), but in a framework which allows for stochastic influences. After all it might be these stochastic factors (both observed and unobserved) that are driving the results in both Figure 4 and Figure 5; without taking account of these effects it is neither possible to suggest that Figure 4 rejects the neoclassical view nor that Figure 5 supports, at least partially, the neoclassical view.

Thus, instead of using only a scatter plot of $\pi^*$ against $\pi$ to test the viability condition, I test the relationship implied by the viability condition in terms of averages, i.e., using conditional expectations. Thus, instead of testing whether $\pi^* = \pi$ in a cross-country scatter plot, I use a stochastic version of that test; thus, I test whether $E[\pi^*|\pi] = \pi$, where $E[y|x]$ denotes the conditional expectation of $y$ given $x$. Instead of testing the relationship implied by the viability condition exactly I test whether, on average, $\pi^*$ is equal to $\pi$ in the sample of countries for which I have data. A cross-country regression model would, therefore, be a natural device to use for this purpose.
5.2 Empirical Model

From (3) we can see that the viability parameter, $\pi^*$, is a function of the growth rates of labour and capital productivity; thus $\pi^*$ is a variable that is affected by the rate of technical change in the economy. In the classical vision, technical change is driven by conflict between the social classes (workers and capitalists) over the distribution of national income; hence, we can think of the variable $\pi^*$ as being determined, in the long run, by the share of profits in national income. The implication of the classical vision is that in the relationship between the viability parameter and the profit share, causality runs from the profit share to the viability parameter $\pi^*$, rather than the other way round. We can use this observation to recast the viability condition into a cross-country regression model as,

$$\pi^*_i = \alpha + \beta_1 \pi_i + \varepsilon_i, \quad i = 1, 2, \ldots, n,$$

where $i$ indexes country, and $n$ is the number of countries in the sample, $\pi^*_i$ is the viability parameter for country $i$, $\pi_i$ is the share of profits in country $i$ and $\varepsilon_i$ are unobserved stochastic factors that affect the viability parameter. Note that this model implies that the conditional expectation of the viability parameter, $\pi^*$, given $\pi$ is a linear function of $\pi$ and a constant, i.e., $E[\pi^*|\pi] = \alpha + \beta_1 \pi$, where $\alpha$ and $\beta$ are parameters to be estimated from the data. Since the neoclassical view of growth and distribution implies that, on average, the viability parameter is equal to the profit share, i.e., $E[\pi^*|\pi] = \pi$, we can test the classical versus the neoclassical view, in this framework, by testing the following joint null hypothesis: $H_0 : \alpha = 0; \beta_1 = 1$. Failure to reject the null would lend support to the neoclassical view, while rejecting the null would provide evidence against it.

This analysis can be extended further by controlling for another set of country-specific factors. There is a large literature on induced technical change that I am implicitly drawing on to derive my empirical model; early contributors include Hicks (1932); Kennedy (1964) and Drandakis and Phelps (1965). This literature has been recently revived by, among others, Acemoglu (2002); Acemoglu (2003); Foley (2003); and Tavani (2008).
factors that can potentially account for the variation of $\pi^*$ and $\pi$ across countries: variables that capture the level or depth of capitalist development in a country. To control for the level of capitalist development across countries, therefore, I include two additional regressors: the average level of labour productivity and the average total fertility rate per woman, both averages computed between 1963 and 2000.\textsuperscript{11} The rationale for using these two covariates is that both, the average labour productivity and the average fertility rate, can be expected to be highly correlated with the depth of capitalist development across countries; advanced capitalist countries can be generally expected to have high labour productivity and low fertility rates, whereas countries that have not witnessed broad-based capitalist development will generally have low labour productivity and high fertility rates. Including these in our regression, therefore, controls for the level of capitalist development, which might be an important source of variation in a scatter plot such as Figure 5. The extended model is, therefore, given by

$$\pi_i^* = \alpha + \beta_1 \pi_i + \beta_2 x_i + \beta_3 f_i + \epsilon_i, \quad i = 1, 2, \ldots, n,$$

(10)

where $i$ indexes country, $x_i$ is the average labour productivity for country $i$, $f_i$ is the average fertility rate for country $i$ and $n$ are the number of countries in the sample. This extended model implies that the conditional expectation of $\pi^*$ given $\pi$ is a linear function of a constant, $\pi$, $x$, and $f$, i.e., $E[\pi^*|\pi] = \alpha + \beta_1 \pi_i + \beta_2 x_i + \beta_3 f_i$. To test the neoclassical view of technical change and income distribution, using the extended model, I test the following joint null hypothesis: $H_0: \alpha = 0; \beta_1 = 1; \beta_2 = 0; \beta_3 = 0$; this, again, is equivalent to testing that $E[\pi^*|\pi] = \pi$. As before, failure to reject the null would lend support to the neoclassical view, while rejecting the null would provide evidence against it.

\textsuperscript{11}In the EPWT 2.1, fertility is measured by the total fertility rate per woman.
5.2.1 Geometric Intuition

It is possible to offer some geometric intuition for the econometric test that has been proposed in this paper. Taking account of stochastic influences, the classical-Marxian viability condition for technical change can be seen to assert that the conditional mean of the viability parameter is greater than the share of profits; the neoclassical view, on the other hand, amounts to the proposition that the conditional mean of the viability parameter is equal to the share of profits. In the bivariate context, i.e. when the conditional mean of the viability parameter is specified to be a linear function of a constant and the share of profits, the neoclassical view suggests that the conditional mean of the viability parameter is a straight line passing through the origin and having a slope of unity. When, therefore, I test the null hypothesis, $H_0: \alpha = 0; \beta_1 = 1$, I test the proposition that the conditional mean of the viability parameter, parametrized as an affine function of the share of profits, is statistically indistinguishable from a straight line with a slope of unity passing through the origin.

The same geometric intuition carries over to the case of a multiple regression. For instance, the 3-dimensional analogue of a straight line with a slope of unity passing through the origin is a plane passing through the origin which intersects every $z$-plane (i.e., a plane defined by $z = k$, where $z$ is the $z$-axis and $k$ is any constant) along a straight line with slope of unity and passing through the origin (for the $z$-plane). The 3-dimensional analogue of a straight line with a slope of unity passing through the origin can therefore be represented as the following set of points:

$$\{(x, y, z)|x = y, z = k\}$$

where $(x, y, z)$ refer to the three coordinate axes and $k$ is any constant (real number). Now,
any plane in 3-dimensional space can be represented as

\[ ax + by + cz = d \]

where \((x, y, z)\) again refer to the three coordinate axes and \(a, b, c, d\) are some constants. The restrictions on this general equation of the plane that gives us the 3-dimensional analogue of a straight line with a slope of unity passing through the origin are: \(c = d = 0\) and \(a = b\). In a multiple regression setting, \(y\) would represent the conditional mean of the dependent variable and \(x, z\) would be the independent (or conditioning) variables.

Now, in a (linear) multiple regression setting, the conditional mean of the viability parameter is parametrised as a plane. For instance, if the viability parameter is understood as being affected, on average, by the share of profits, \(\pi\), and the average fertility, \(f\), then the conditional mean of the viability parameter is given as

\[ E[\pi^*|\pi, f] = \alpha + \beta_1\pi + \beta_2 f. \]

Here, the conditional mean of the viability parameter is geometrically specified as a plane in 3-space. To make this plane the 3-dimensional analogue of a straight line with a slope of unity passing through the origin (as in the bivariate regression context) is to put the restrictions that

\[ \alpha = 0, \beta_1 = 1, \beta_2 = 0. \]

The same intuition is valid for cases with more than 2 conditioning variables, i.e., when we operate in spaces with more than 3 dimensions.
5.3 Data and Results

Data for our empirical analysis comes from four sources: (1) the Extended Penn World Tables (EPWT 2.1), (2) the Barro-Lee data set, (3) the cross country data set used in Easterly and Levine (2003), and (4) the United Nations Industrial Development Organization (UNIDO) industrial database. From the EPWT 2.1, I take data on labour productivity, capital productivity, profit share and fertility rates; from the Barro-Lee data set, I take data on educational attainment; from Easterly and Levine (2003), I take data on measures of international openness and institutional quality; and from the UNIDO industrial data base, I take data on profit share for countries which lacked this data in the EPWT 2.1.\textsuperscript{12}

Estimation results of the basic empirical analysis are reported in Table 2, 3, 4 and 5.\textsuperscript{13} Whereas conventional cross-country growth regressions study the effect of covariates on either the level or growth of per capita income, the objective of my empirical analysis is a different one. Recall that the analysis in this paper is an attempt to econometrically test the neoclassical view of capital-labour substitution against the alternative classical view based on Marx-biased technical change. The null hypothesis corresponding to the neoclassical view can be tested using a F-statistic testing the joint null which corresponds to the conditional expectation of the viability parameter being equal to the share of profits. Hence my interest, in this paper, is not so much in the coefficient estimates, which have been estimated by OLS, as in the value of the F-statistic reported in the last row of Table 2, 3, 4 and 5. Coefficient estimates would have been relevant if I had framed my analysis like a cross-country growth regression.

The F-statistic reported in the last row of Tables 2, 3, 4 and 5 tests, in each case, the null hypothesis corresponding to the neoclassical theory of marginal productivity: \(E[\pi^*|\pi] = \pi\). Thus in the bivariate regression model represented by (9), the null is \(H_0: \alpha = 0; \beta_1 = 1\); with

\textsuperscript{12}Details about the data used in this paper have been provided in the appendix.

\textsuperscript{13}Data and R code for the estimation is available from the author upon request.
labour productivity and the fertility rate as additional regressors in the extended model in (10), the null is $H_0: \alpha = 0; \beta_1 = 1; \beta_2 = 0; \beta_3 = 0$. Under the assumption that the error term in the regression is i.i.d. and independent of the regressors, the F-statistic is distributed as a $F(m, n - k)$ random variable, where $m$ is the number of linear restrictions, $n$ is the number of observations and $k$ is the number of regressors. Since the problem of heteroskedastic errors often crop up in cross-sectional regression settings, all standard errors reported in this paper have been corrected for possible heteroskedasticity using White (1980); the F-tests have thus been conducted using heteroskedasticity consistent (HC) standard errors.

I report results separately for two different groups of countries. The first group consists of 25 advanced capitalist countries which are part of the OECD; the second, larger, group consists of 117 countries which had relatively complete data for the relevant variables in the EPWT 2.1, and thus includes the OECD countries as a sub-group.\textsuperscript{14} For both groups of countries, I report two different regressions, one corresponding to the simple model in (9) and the other corresponding to the extended model in (10); the results are presented in Table 2.

For the OECD countries, the F-statistic in the simple model is 11.933 and for the extended model is 5.564; thus, in both models, the null hypothesis can be rejected at the one percent level of significance, confirming the results of Foley and Michl (1999). For the larger group of countries, the F-statistic in the simple model is 15.258; thus we can reject the null corresponding to the neoclassical theory very strongly even though Figure (5) lent apparent support to the neoclassical view of distribution. Even when we include the additional regressors to control for the level of capitalist development, the F-statistic is 12.259; though smaller than for the simple model, it is still large enough to reject the null at the one percent level of significance.

\textsuperscript{14}Countries which did not have profit share data, either in the EPWT 2.1 or in the UNIDO industrial data base, have been left out of the regression analysis.
Table 2: Estimation Results, 1963-2000

<table>
<thead>
<tr>
<th></th>
<th>OECD</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>1.131</td>
<td>0.060</td>
</tr>
<tr>
<td></td>
<td>(0.507)</td>
<td>(1.389)</td>
</tr>
<tr>
<td>PROFIT SHARE</td>
<td>-0.605</td>
<td>1.365</td>
</tr>
<tr>
<td></td>
<td>(1.050)</td>
<td>(1.781)</td>
</tr>
<tr>
<td>LABOUR PRODUCTIVITY</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>FERTILITY</td>
<td>-0.139</td>
<td>-0.140</td>
</tr>
<tr>
<td></td>
<td>(0.149)</td>
<td>(0.070)</td>
</tr>
</tbody>
</table>

N 26 26 83 83

F-statistic 11.933 5.564 15.258 12.259

(1) Dependent variable is $\pi^*$; for details of model see (9) and (10).
(2) For parameter estimates, HC standard errors in brackets.
(3) For the F-statistic, HC p-values in brackets.

Recall that Proposition 1 states that if the neoclassical view of distribution is rejected for a situation with stagnant wages, then it will also be rejected for a case where entrepreneurs expect the wage rate to grow. The empirical analysis has so far been conducted with the assumption that the wage rate is not expected to grow, as was implicitly assumed to derive (3). Now, I will carry out a similar empirical analysis with (5) instead of (3), to allow for the fact that entrepreneurs might expect wages to grow. In this case, the empirical model is

$$\pi^*_{1,i} = \alpha + \beta_1 \pi_i + \varepsilon_i, \quad i = 1, 2, \ldots, n,$$

(11)

for the simple scenario and

$$\pi^*_{1,i} = \alpha + \beta_1 \pi_i + \beta_2 x_i + \beta_3 f_i + \varepsilon_i, \quad i = 1, 2, \ldots, n,$$

(12)

for the more general scenario allowing for the level of capitalist development to affect the
cross-country variation of the viability condition. Note that in both (11) and (12), the dependent variable is \( \pi^*_1 \), where \( \pi^*_1 \) is the viability parameter defined in (8); the independent variables are exactly as before. Results for these models are presented in Table (3).

**Table 3: Estimation Results, 1963-2000**

<table>
<thead>
<tr>
<th></th>
<th>OECD</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>(2)</td>
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<tr>
<td>CONSTANT</td>
<td>0.875</td>
<td>0.890</td>
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<tr>
<td></td>
<td>(0.291)</td>
<td>(0.655)</td>
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<tr>
<td>PROFIT SHARE</td>
<td>0.107</td>
<td>0.626</td>
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<tr>
<td></td>
<td>(0.608)</td>
<td>(0.778)</td>
</tr>
<tr>
<td>LABOUR PRODUCTIVITY</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>FERTILITY</td>
<td>-0.101</td>
<td>-0.139</td>
</tr>
<tr>
<td></td>
<td>(0.060)</td>
<td>(0.071)</td>
</tr>
<tr>
<td>N</td>
<td>28</td>
<td>28</td>
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<tr>
<td>F-statistic</td>
<td>69.211</td>
<td>31.762</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
</tbody>
</table>

(1) Dependent variable is \( \pi^*_1 \); for details of model see (11) and (12).
(2) For parameter estimates, HC standard errors in brackets.
(3) For the F-statistic, HC p-values in brackets.

As expected by Proposition 1, the results in Table (3) reject the neoclassical view even more strongly. The value of the F-statistic in all the four cases, which are greater than the corresponding values in Table (2), suggest that the null hypothesis corresponding to the neoclassical view can be easily rejected at the one percent level of confidence.

In Tables (4) and (5), I report results for the same empirical analysis but now carried out on a restricted sample of countries: countries which witness, for the period 1963 – 2000 as a whole, Marx-biased technical change. This restricted sample of countries is extracted from whole data set in the following manner: all countries for which we have \( g_x \geq 0 \) and \( g_\rho \leq 0 \), are included in this restricted sample, where \( g_x \) is the growth rate of labour productivity between 1963 and 2000, and \( g_\rho \) is the corresponding figure for capital productivity. Along expected lines, the empirical analysis for the restricted set of countries, i.e., the countries...
which display Marx-biased technical change rejects the neoclassical theory equally strongly.

<table>
<thead>
<tr>
<th></th>
<th>OECD</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
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<tr>
<td>CONSTANT</td>
<td>0.975</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.349)</td>
<td>(0.990)</td>
</tr>
<tr>
<td>PROFIT SHARE</td>
<td>-0.627</td>
<td>0.774</td>
</tr>
<tr>
<td></td>
<td>(0.720)</td>
<td>(1.232)</td>
</tr>
<tr>
<td>LABOUR PRODUCTIVITY</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>FERTILITY</td>
<td>-0.050</td>
<td>-0.047</td>
</tr>
<tr>
<td></td>
<td>(0.055)</td>
<td>(0.027)</td>
</tr>
<tr>
<td>N</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>F-statistic</td>
<td>11.567</td>
<td>5.178</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.003)</td>
</tr>
</tbody>
</table>

(1) This is the same model as in Table 2 estimated for countries which display MBTC.
(2) For parameter estimates, HC standard errors in brackets.
(3) For the F-statistic, HC p-values in brackets.

5.3.1 Robustness Checks

The basic empirical analysis of this paper demonstrated that the neoclassical marginal productivity theory of income distribution is strongly rejected by the data. The classical-Marxian theory of biased technical change suggested two kinds of covariates that could affect the viability parameter: the share of profits in national income (as a proxy for the intensity of class struggle) and a group of covariates that could capture the depth of capitalist development. In the analysis so far, I have used two covariates to capture the depth of capitalist development: the average level of labour productivity and the average level of total fertility per woman. In this section, I use additional regressors that have been thrown up in the recent literature on cross-country growth empirics to test whether these additional controls significantly affect the basic result of this paper.
The recent growth empirics literature has used several interesting covariates to account for the cross-country variation in per capita income levels and its growth rate. Among the most common are the following: a measure of educational attainment of the population as a proxy for ‘human capital’, a measure of openness to the international flow of goods and services, and a measure of the quality of institutions in the country. I augment the basic data from the EPWT2.1 with data on educational attainment from the Barro-Lee data set, and measures of openness and institutional quality from Easterly and Levine (2003). Several countries in the EPWT 2.1 lacked data on income shares; for these countries I have filled this gap with wage share data for the manufacturing sector for the late 1990s from the UNIDO industrial statistics data base.

Table 5: Estimation Results, 1963-2000

<table>
<thead>
<tr>
<th></th>
<th>OECD (1)</th>
<th>OECD (2)</th>
<th>OECD (3)</th>
<th>OECD (4)</th>
<th>ALL (5)</th>
<th>ALL (6)</th>
<th>ALL (7)</th>
<th>ALL (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>0.832</td>
<td>0.756</td>
<td>0.888</td>
<td>1.112</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.199)</td>
<td>(0.167)</td>
<td>(0.136)</td>
<td>(0.170)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROFIT SHARE</td>
<td>0.039</td>
<td>0.452</td>
<td>-0.326</td>
<td>0.050</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.397)</td>
<td>(0.240)</td>
<td>(0.246)</td>
<td>(0.245)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LABOUR PRODUCTIVITY</td>
<td>0.000</td>
<td></td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FERTILITY</td>
<td>-0.058</td>
<td></td>
<td>-0.095</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td></td>
<td>(0.022)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>20</td>
<td>20</td>
<td>51</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>101.300</td>
<td>224.2400</td>
<td>29.912</td>
<td>75.303</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

(1) This is the same model as in Table 3 estimated for countries which display MBTC.
(2) For parameter estimates, HC standard errors in brackets.
(3) For the F-statistic, HC p-values in brackets.

Results for this extended data set is presented in Table 6. It is interesting and reassuring to note that the basic result of this paper does not change when we include additional controls and alternative proxies for the depth of capitalist development. Note that the most relevant statistic to look at in Table 6 is $F_2$, which is the $F$-statistic that tests the neoclassical against
the classical-Marxian view of capital-labour substitution and income distribution. In all the regressions we can see that this statistic is significant. This implies, as before, that the null hypothesis corresponding to the neoclassical view can be rejected with a high degree of confidence. Since the aim of this paper is not to study the effect of covariates on the viability parameter, I will not try to interpret the sign or significance of the coefficient estimates.

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>1.044</td>
<td>1.456</td>
<td>1.359</td>
<td>1.989</td>
<td>1.709</td>
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<td>PROFIT SHARE</td>
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<td>-0.127</td>
<td>0.047</td>
<td>0.047</td>
<td>-0.018</td>
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<tr>
<td>LABOUR PRODUCTIVITY</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>FERTILITY</td>
<td>-0.139</td>
<td>-0.153</td>
<td>-0.230</td>
<td>-0.185</td>
<td>-0.185</td>
</tr>
<tr>
<td>SCHOOLING</td>
<td>0.033</td>
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<tr>
<td>OPENNESS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INSTITUTION QUALITY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.005</td>
</tr>
</tbody>
</table>

| N                      | 83        | 82        | 69        | 48        | 48        |
| Multiple $R^2$         | 0.029     | 0.165     | 0.164     | 0.178     | 0.145     |
| $F_1$                  | 2.385     | 5.131     | 3.6130    | 2.317     | 1.820     |
| $F_2$                  | 15.258    | 12.224    | 10.296    | 5.458     | 3.633     |

(1) The model is (10) with additional relevant controls.
(2) For parameter estimates, heteroskedasticity consistent (HC) standard errors in brackets.
(3) $F_1$ measures the joint significance of all the regressors; HC p-values in brackets.
(4) $F_2$ is the statistic for the test of the neoclassical model; HC p-values in brackets.
6 Conclusion

In the last decade, economists working in the classical-Marxian tradition have developed a coherent and consistent alternative framework for studying long-run economic growth of capitalist economies. This alternative framework is informed by the deep critique of neoclassical theory inaugurated by the Cambridge controversy of the 1950s and 1960s. One important proposition about the process of biased technical change in capitalist economies that emerges from this alternative framework is the viability condition. The viability condition nests both the neoclassical and the classical-Marxian theories of distribution. Hence, the viability condition can be utilised to devise an empirical test among these competing views of capital-labour substitution and theories of income distribution.

Using the classical viability condition, this paper builds on the work of Foley and Michl (1999) by proposing a simple econometric test of the alternative theories of distribution. Of course, the limitation of the method used in this paper is that it tests a specific version of neoclassical theory, one without neutral technical change, against the classical theory based on Marx-biased technical change; it cannot be used when neutral technical change is incorporated into the neoclassical framework. Devising empirical tests to distinguish neoclassical theory with neutral technical change from the corresponding classical theory with biased technical change is a challenging project that awaits scholarly attention and work.

Using data from the EPWT2.1, I find that my test overwhelmingly rejects the neoclassical theory of distribution (which asserts that the wage rate is equal to the marginal product of labour) not only for the OECD countries, but even for a larger group of countries. When I restrict the empirical analysis to the countries which display, on average, Marx-biased technical change, the neoclassical view is rejected even more strongly.

One issue that needs to be addressed is the well known problem in empirical economics
that income shares are not very precisely estimated for less developed countries (e.g., see Gollin (2002) and the references therein); labour’s share in national income is usually underestimated. The problem of underestimation arises because small firms and self-employed individuals do not report wages as part of compensation, thereby underestimating the share of wages in aggregate data. It is therefore possible that the data on the share of wages or profits that is presented in the EPWT2.1 suffers from similar problems. An alternative to using data on income shares from the EPWT2.1 is to construct the series for labour’s share in income from the UNIDO industrial statistics database as done in Decreuse and Maarek (2008) or from other sources as done by Gollin (2002). This issue has been partially addressed in this paper and can be explored further in future research.

Appendix

The basic data for our empirical analysis comes from the Extended Penn World Tables (EPWT 2.1). The EPWT 2.1, prepared by Adalmir Marquetti, supplements the Penn World Tables 6.1 (PWT 6.1), by including data on capital stocks, distribution of national income and population growth. Data for most countries in the EPWT 2.1 start at 1963 and go all the way to 2000; for some countries the data series starts later because sources for earlier periods were not available. I use data on labour productivity, capital productivity, profit share and fertility rates from the EPWT 2.1 for this analysis. This data is augmented by data from three other sources: the Barro-Lee data set on educational attainment, data on the wage share in income for manufacturing industries from the United Nations Industrial Development Organization (UNIDO) industrial database and the cross-country data set used by Easterly and Levine (2003) which contains two variables relevant for the present analysis: measures of international openness and measures of institutional quality.\footnote{The Barro-Lee data set is available for download from the Center for International Development, Harvard University at this website: \url{http://www.cid.harvard.edu/ciddata/ciddata.html}; the data set...}
the variables used are as follows:

1. Share of Profits: Using the wage share data from the EPWT 2.1, I defined the “share of profits” as follows: 
\[(\text{share of profits}) = (1 - \text{share of wages})\]. For the following countries, the data on share of wages was not available in the EPWT 2.1 and has been taken from the UNIDO industrial database: Argentina, Bangladesh, Barbados, Cyprus, El Salvador, Ethiopia, Gambia, Ghana, Indonesia, Iran, Madagascar, Pakistan, Singapore and Taiwan.

2. Labour Productivity: This data is taken from the EPWT 2.1 where it is defined as the ratio of the GDP to the working population; it is measured in the following unit: 1996 PPP $ per worker-year.

3. Capital Productivity: This data is taken from EPWT 2.1 and is the ratio of the GDP to the estimated net standardized fixed capital stock both measured in 1996 PPP $.

4. Viability Parameter: This is computed using the growth rates of labour productivity and capital productivity using the formula given in the text of the paper.

5. Fertility: This data is taken from EPWT 2.1 where it is defined as total fertility rate per woman.

6. Schooling: This data is taken from the Barro-Lee data set where this variable (educational attainment) is defined as the average years of schooling for the population above 25 years of age.

7. Openness: This data is taken from Easterly and Levine (2003) and is a measure, for each country, of the economic integration with the rest of the world; it is measured as used by Easterly and Levine (2003) is available for download from the webpage of Ross Levine at: http://www.econ.brown.edu/fac/Ross_Levine/Publications.htm#2005. Note that Easterly and Levine (2003), in turn, have borrowed data from Acemoglu, Johnson and Robinson (2001).
the fraction of years between 1960 and 1994 a country has been “open”, as defined by Sachs and Warner (1995).

8. Institution Quality Index: This is taken from Easterly and Levine (2003) and is an average of (1) the six Kaufman, Kraay, and Zoido-Lobaton (1999a; 1999b) measures: (i) voice and accountability, (ii) political instability and violence, (iii) government effectiveness, (iv) regulatory burden, (v) rule of law, and (vi) graft, and (2) one of the three policy variables: inflation, trade openness, or real exchange rate overvaluation. The method used to calculate the index gives it an approximately unit normal distribution, with a higher value of the index always signifying better quality of institutions.

Summary statistics for the important variables are presented in Table 7 and Table 8 for the OECD and all countries respectively. OECD, in our sample, is composed of the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and USA.

<table>
<thead>
<tr>
<th>Table 7: Summary Statistics: OECD Countries</th>
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<tr>
<td>Mean</td>
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<tr>
<td>VIABILITY PARAMETER</td>
</tr>
<tr>
<td>CAPITAL PRODUCTIVITY</td>
</tr>
<tr>
<td>PROFIT SHARE</td>
</tr>
<tr>
<td>LABOUR PRODUCTIVITY</td>
</tr>
<tr>
<td>FERTILITY</td>
</tr>
<tr>
<td>SCHOOLING</td>
</tr>
<tr>
<td>OPENNESS</td>
</tr>
<tr>
<td>INSTITUTION QUALITY</td>
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</table>
Table 8: Summary Statistics: All Countries

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>Min</th>
<th>Std Dev</th>
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<tr>
<td>VIABILITY PARAMETER</td>
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<td>8.68</td>
<td>0.38</td>
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<tr>
<td>PROFIT SHARE</td>
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<td>0.53</td>
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<tr>
<td>LABOUR PRODUCTIVITY</td>
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<td>13900.95</td>
<td>53240.08</td>
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<tr>
<td>FERTILITY</td>
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<td>4.63</td>
<td>7.69</td>
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<td>1.86</td>
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<tr>
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<td>OPENNESS</td>
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<td>1.00</td>
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<td>−0.13</td>
<td>1.59</td>
<td>−1.18</td>
<td>0.67</td>
</tr>
</tbody>
</table>

References


